

# Designing the social life cycle of products from the systematic competitive model

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## Abstract

**Purpose** Changes affecting how product chains function can have a profound impact on human communities. Certain social life cycle assessment (LCA) methods aim to anticipate the important social effects of changes taking place in the functioning of a product's life cycle. They therefore must identify the groups that are most affected. This paper aims to help identify the groups affected by competition beyond those usually highlighted. The objective is to propose rules to identify the organisations involved in the social life cycle of a product within a context of competition. Once these organisations are identified, it is possible to deduce which groups are affected.

**Methods** We analyse how published social LCA studies describe the product system and determine its boundaries. We deduce the necessity of constructing (1) a new model (the systematic competitive model) when there is competition and (2) a cut-off criterion (significant dependency). These allow us to describe the system and determine its boundaries, and thus to draw the social life cycle, in a context of competition. We conducted a simple case study

(calculation of the number of rural jobs created/destroyed by a new agricultural *filière*) in which two methods of representing a product system are compared. The first method is the value chain (which does not take into account the situation prior to the establishment of the planned new *filière*), the second method introduces the systematic competitive model, which includes the short term effects of competition with the planned activities.

**Results** The case study shows that it is possible to define the social life cycle by proceeding in this way. The two ways of representing the same real system produce very different results. The list of organisations affected and the nature of the impact to be assessed determine which actors are affected.

**Conclusions** The use of the systematic competitive model is indispensable when competition is intense. The organisations to be included in the boundaries of the social LCA (SLCA) study are those whose behaviour with social effects is significantly affected by the changes. Furthermore, there are numerous other phenomena linked to products that provoke important social impacts, but we do not yet know how to model them. They call for further research. Environmental LCA (ELCA) and SLCA studies of the same real system will be coherent, even if the descriptions of the system and the rules of fixing the boundaries differ, provided they reflect the same scenario.

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## 1 Introduction

“This country is going to establish agreements with a large multinational firm to increase its production of palm oil. The

company will have to expropriate 20,000 households to expand its own plantations. This will lead to the displacement of the population and considerable food insecurity.”

“These shepherds from the Sahel sell their milk in a neighbouring town. Soon, a foreign company will deliver milk to the town. The shepherds will lose a valuable market.”

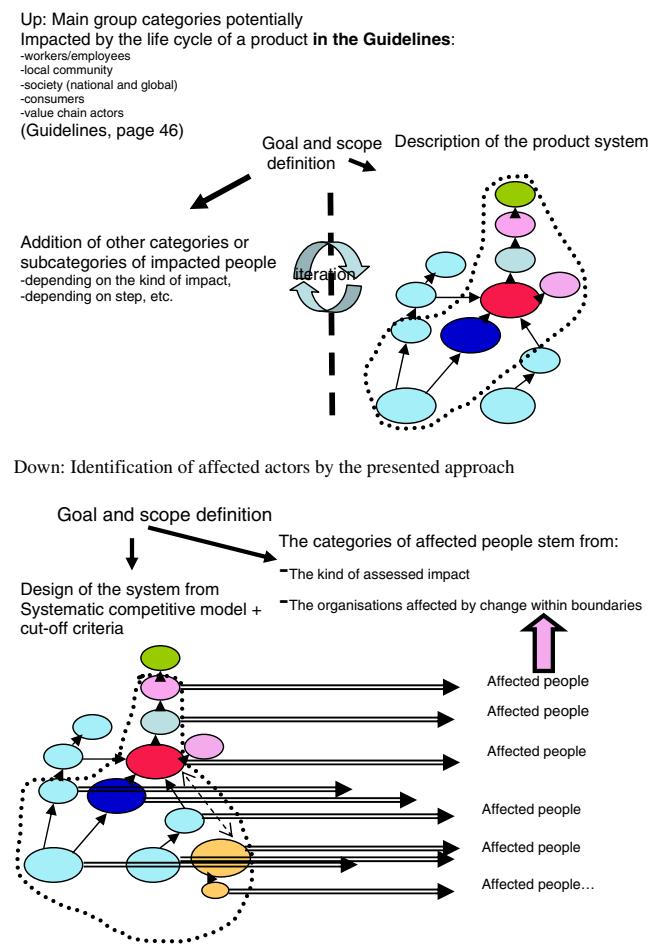
We take the position that one sincerely wishes to know potentially important social impacts of changes induced by the functioning of a product chain. The two preceding examples illustrate phenomena (expropriation, loss of markets) that therefore must be identified. This is a key challenge for future social LCA methods (referred to henceforth as SLCA). In line with the second SLCA seminar (Montpellier, May 2011), we see SLCA as a rapidly developing field of research within the conceptual LCA framework. This paper addresses only the SLCA methods that aim to design and test methods for assessing potential social impacts caused by changes in the functioning of product chains. The method is based on a comparison of several alternatives for providing the same service, as highlighted by Weidema (1993) for environmental life cycle assessment (ELCA). This article aims to contribute to defining rules for the description of a product system and the definition of boundaries. According to the ISO guidelines in ELCA, the product system is a set of basic processes comprising flows of products and basic flows, filling one or several defined functions, which serves as the model for the life cycle of a product and boundaries of the system are the ensemble of criteria that specifies the basic processes that are part of the product system (ISO 2006). In other words, we search for the design of a product's social life cycle. It will be useful for methods baptised “SLCA of pathways” (Parent et al. 2010), and which proceed by comparing different states of the functioning of a product chain. The state evaluated always acknowledges a baseline, which could be a different activity volume, or even the non-existence of the activity (Jeorgensen et al. 2010). Within this paper, we prefer the term of actor affected to that of “stakeholders” which alludes to different concepts.

How may “indirect impacts” as defined by Ekvall (2000)<sup>1</sup> be taken into account? The SLCA guidelines (UNEP/SETAC 2009) propose a minimal list of five categories of actors affected that may be fleshed out with other groups, or refined into sub-categories depending on the context. In the example above, this may be dispossessed farmers and Fulani pastoralists. The danger of this approach is that it has not been systematised. Consultants and researchers risk unintentionally overlooking some seriously affected actors, and therefore miss the *principal social*

impacts of a product, either because they are unaware of the phenomenon, or because the commissioner of the study would prefer to gloss over it. Yet the legitimacy of SLCA lies in its capacity to grasp indirect effects. “Externalities [indirect effects upon people] are the zone of conflict, and deciding where to draw the boundary is *the fundamental question for sustainability*” (Swarr 2009, p. 287).

We propose a systematic approach in which the definition of the social life cycle of a product (description of a system and fixing the boundaries) precedes and conditions the choice of actors affected. In the guidelines book, there does not seem to be a direct link, although iterations between examining the boundaries and the definition of sub-categories are possible. The question of people affected is addressed on pp. 45–49, and that of the definition of the system on pp. 58–60 (English version). Figure 1 graphically presents the differences between the two propositions.

The approach proposed is suitable in situations where the central firm of the activity being assessed faces competition from other organisations. The diverse natures of these



**Fig. 1** Representations of the system and identification of actors affected in the SLCA guidelines approach (*up*) and the proposed approach (*down*)

<sup>1</sup> From Ekvall (2000), indirect impacts are environmental consequences that are outside of the physical supply chain and result from market forces.

competition effects are discussed in paragraph 3 of Electronic Supplementary Material 1.

To elaborate the social life cycle of a product, we follow a two-step approach: (1) we propose a model that allows the product system involved to be represented in such a way as to include all organisation likely to enter into the boundaries of the study; (2) we propose a cut-off criterion that allows the boundaries to be set.

The paper is organised into six sections. In Section 2, we review the practices commonly used to describe a system and set boundaries in published SLCA studies (whether or not SLCA of pathways are involved). As one will see, the descriptions often rely on the value chain concept borrowed from Porter (1985). However, there are other types of strategic analysis. Their potential contribution to the definition of a social life cycle is the question addressed in Electronic Supplementary Material 1. In Section 3, we draw from this review to propose a new model, the *systematic competitive model* of the product system. It relies on the concept of the *central firm* already discussed by Dreyer et al. (2006), and combines the *value net model* (Brandenburger and Nalebuff 1996) with that of the *strategic arena* (Rotschild 1984). The resulting model includes the chains belonging to firms competing with the central firm. We also suggest *cut-off criteria* (of significant dependency) to eliminate some organisations from the boundaries of the study. Applied together, the new model and the cut-off criteria draw the social life cycle. We deduce from it the actors affected. In Section 4, we present a simple case study to illustrate the differences between the value chain systems approach and that of the systematic competitive model. Details of the calculations are given in Electronic Supplementary Material 2. We present the results, discussion and conclusion in Sections 5 and 6.

## 2 Conceptualisation of the system and setting boundaries in SLCA

SLCA studies aim to take into account all of the life cycle stages described in ELCA (from birth to eventual recycling). However, the usage stage is rarely modelled. Following the example of Dreyer et al. (2006), we exclude this stage due to its specific features. In Section 1, working from an economic and social science perspective, we present the way published SLCA literature generally represent and then set the boundaries of the systems assessed.

### 2.1 One-dimensional analysis to represent the system

#### 2.1.1 Units and flows

According to Parent et al. (2010), the processes involved in the life cycle of the product stem from either unit processes or economic activities.

Hunkeler (2006) describes the system as a succession of unit processes. The flows taken into account are those of the product, materials, water and energy, like in ELCA. Benoît et al. (2010) also describe the same flows, but specific sectors and organisations may be part of the analyses in respect to the themes of interest.

Other authors prefer to describe the system from the perspective of economic activities. Dreyer et al. (2006, 2010) explicitly compare the representations of a system in ELCA and SLCA. They believe one should represent the system as a set of organisations because “social impacts on people in the life cycle of a product have a more clear relation to the conduct of the companies involved in the product chain—and to the way the companies organise and manage their business” (Dreyer et al. 2006, p. 89). The description of the system therefore involves a number of individual companies where industrial processes take place. They focus attention on the same flows between companies as in ELCA (see Figs. 1 and 2, p. 89 in Dreyer et al. 2006). Some authors add financial flows (Andrews et al. 2009).

These representations are rooted in concepts used by economists to describe the ensemble of activities that follow one after another in the conception–production–distribution process of a good or service, from the raw materials to the consumer. However, the disposal stage often is not addressed in economic literature, while SLCA authors nearly always consider it.

LCA studies (both environmental and social) that break the system down into unit processes, organisations or activities linked by flows often rely on the value chain concept and its derivatives.

#### 2.1.2 The value chain and the value system

Developed by Porter in the 1980s (Porter 1985), the famous *value chain* concept is based on the idea that every organisation is constituted by chains of client–supplier relationships, each aiming to add value to the product or service finally sold. She thus describes the complete range of activities that take place one after another from conception to delivery to clients. Value chain analysis was created mainly to identify the sources of value creation, positive or negative, that contribute to competitive advantage. The *value* is defined as the relationship between the satisfaction of client needs and the associated direct and indirect costs, and results from different activities carried out by suppliers, the firm, and distribution channels, whether these are integrated or not in the central firm (Mitchell et al. 2009). It may be considered in its environmental, social, and cultural dimensions.

This model is used widely in SLCA. Ciroth and Franze (2011) implicitly base their study of an eco-label notebook on the value chain. They describe the succession of

activities considered. “The S-LCA considers the extraction of raw materials, the production of basic materials and intermediate products, and the assembly of the end product as well as the end-of life phase” (p. 28). Kruse et al. (2009) delineate the salmon production *value chain* (p. 13) by a chain of client–supplier relations between “fishery” and “farm” on the far left, and “consumer” on the far right. In this case, each function coincides with an organisation (real or fictitious). Hofstetter and Norris (2003) use this model to assess occupational health incidence in the plastic and steel sectors in the USA.

To take into account sub-contracting and outsourcing practices, Porter (1985) introduced the *value system* concept. It includes the value chains of a firm's supplier (and their suppliers all the way back), the firm itself, the firm's distribution channels, and the firm's buyers (and presumably extended to the buyers of their products, and so on). Andrews et al. (2009) use the value system to describe the activity sequence of hothouse tomatoes in Canada. They in effect seek a “background data set, into which we can connect our primary data sources to build their supply chain models” (Andrews et al. 2009, p. 568). Dreyer et al. (2006) take into account the suppliers of suppliers (see Fig. 3, p. 91, in Dreyer et al. 2006). Their representation is related to Porter's value system.

## 2.2 Proposals under development to set boundaries

Although the task is critically important (Swarr 2009), contradictory proposals have been suggested for setting boundaries.

### 2.2.1 Boundaries derived from ELCA

It has been written that the boundaries of any system studied through SLCA are or might be similar to those for an ELCA study (O'Brien et al. 1996; Klöpffer 2003; Hunkeler and Rebitzer 2005; Hunkeler 2006). The reasons cited are different, but in general the similarity is said to facilitate the integration of ELCA and SLCA results (Hunkeler and Rebitzer 2005). Maintaining the same boundaries sometimes is presented as a key structural element (Reap et al. 2008, p. 296).

However, the debate is not over. For Reap et al. (2008, p. 296), “the potential to miss important relationships might limit the latter approach [similar boundaries] and selection of key common structural elements may prove less than straightforward.” The guidelines present the two options, counting on future works “to explain the reasons why S-LCA system boundary may or may not differ from E-LCA” (UNEP/SETAC 2009, p. 56).

### 2.2.2 Advocates for a specific SLCA approach

Other authors question the validity of the similarity. Kruse advises expanding “the LCA to also include activities that might have minor impact on environmental results but which are important from a socioeconomic perspective [–]” and disputes the idea that the boundaries are similar. “It may not be reasonable to assume, however, that inputs that are not significant from a biophysical perspective are also not significant from a socioeconomic one [–]” (Kruse et al. 2009, p. 16). Dreyer et al. (2006) suggest that the influence exercised by the central firm (often the manufacturer of the product) is decisive for setting the system's boundaries.

To conclude, the concepts used to describe systems and set the boundaries are not very clear in SLCA literature. Many authors do not clearly explain the conceptual model they have chosen or the criteria on which they have based their choice of boundaries. Yet, these questions are far from trivial ones. “To effectively communicate the criteria for whom and what was included in and excluded from the assessment” is a major credibility factor (Swarr 2009, p. 287).

When the question is raised clearly (Dreyer et al. 2006; Kruse et al. 2009), paths appear, but without a consensus on the response. Published studies do not seem to integrate all of the resources that can be drawn from existing models. They are summarised in Electronic Supplementary Material 1 to determine whether they can help to define rules to describe a system in SLCA.

## 3 Proposal to define the social life cycle of a product and the actors affected

The social life cycle of a product is the system described through a two-step process: the *inclusion* of organisations in response to orders from the *systematic competitive field of the product system* (which is the new model that we propose), followed by the *exclusion* of some using the cut-off criteria. The actors affected are identified on this basis.

First, we shall articulate our position on the nature of the flows exchanged between organisations in the system. In ELCA, the system describes the physical inputs and outputs of unit processes. These are “product, material, or energy flows” (and 3.21 and 3.25 in ISO 2006). In SLCA, the system links organisations by such physical flows, but also by flows of *services*<sup>2</sup> in the *filière* model. All of the models

<sup>2</sup> A service activity mainly is characterised by the offer of a technical or intellectual capacity. Understood in the broadest sense, services cover a wide field of activities that range from commerce to administration, passing through financial and real estate activities, scientific and technical activities, administrative and support services, education, health, and social services. This is the meaning generally understood in the Anglo-Saxon use of the word “services” (INSEE 2011).

that we present in Electronic Supplementary Material 1 link organisations at the minimum by flows of goods and services and their cash counterparts. In addition, in the model that we suggest, there are "flows of interdependence". As we shall see further on, these interdependencies often are grasped by the technical functions that link the economic performances of firms.

### 3.1 Inclusion: the systematic competitive model of the product system

The movements of the central firm (e.g., conquering a new market) will influence the partners accompanying this development, as well as the organisations proposing competing or substitute products on the same markets (role of competitor). Likewise, the suppliers of these actors risk being affected. The elimination or creation of jobs can take place in one or another of these entities. They may subject their workers to a new organisation of work. They may create activities and induce new revenue streams in deprived countries and regions. This is why it is important to build a model that describes (1) all of the relevant present and future players, as well as (2) their own value chains and (3) their dynamics. However, as the business field is characterised by fast paced change, the model only covers a short time span (1 year or less).

The proposed model regroups elements of the *strategic arena* and the *value net* (both presented in Electronic Supplementary Material 1), each compensating for the other's deficiencies. This hybridisation is conceptually acceptable because the two models analyse reality from the same angle, namely they propose a vision of the competitive field that goes beyond the sector. Of course, we do not pretend to recapture the entire wealth of both models. Table 1 summarises the contributions of each to the other.

The *arena* encompasses supply chains that are directly and indirectly competitive through the intermediary of substitutes. It thus defines only part of the width of the competitive field. The *value net* corrects these faults. It highlights the entire span of the field by including all of the roles an organisation may

play. In addition, it describes the "depth" by reproducing changes, which rely on these multiple, entangled roles. In the systematic competitive model of a product system, the height, width and depth of the field are documented (described in detail) as illustrated in Fig. 2.

We use here the example of rice. To fill in the model, the following questions must be answered.

Knowing the central firm, and the planned change in its activities

(1) At the level of customers:

In what arena is the central firm (e.g., the arena of human food needs)? Deducing the organisations that are:

- Its competitors:
  - In its own rice *filière* (e.g., rice I versus rice J)
  - In its own cereal industry (e.g., rice versus wheat)
  - In its own sector (starchy foods) (e.g., rice versus bread)
  - Outside its own sector (e.g., food for humans, rice versus meat)
- Its complementors in all of these spaces (e.g., rice and rice cookers)

Will the envisioned change (during, after) influence the behaviour of these actors? Will new actors enter? If yes, what are their respective value chains?

(2) At the level of the suppliers of the central firm, as well the level of the resources the central firm directly uses (water, land, patents, etc.), what are the organisations that are, in the preceding four spaces:

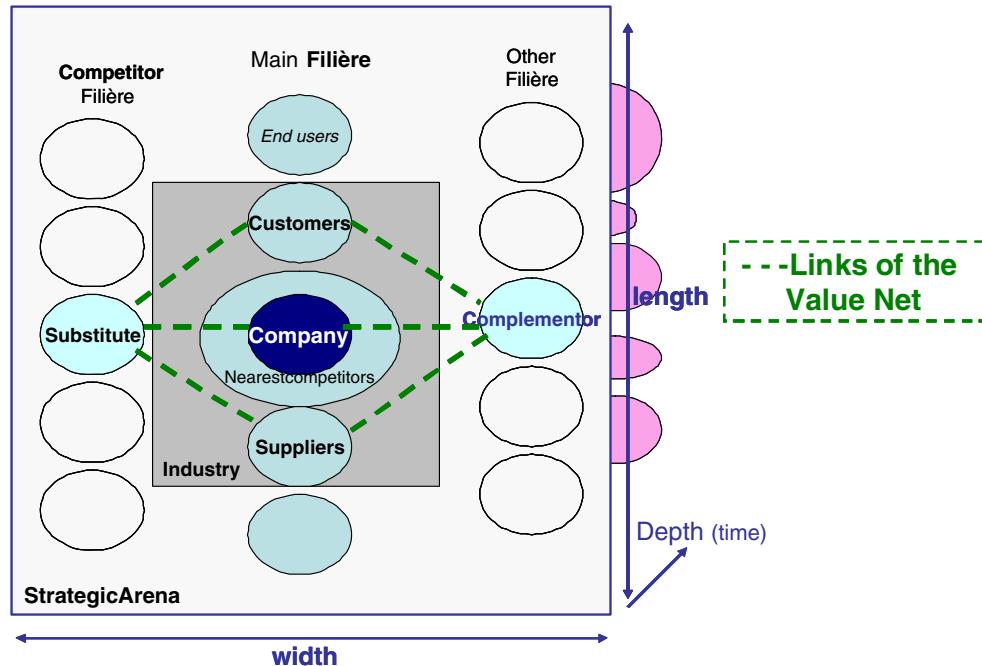
- Its competitors (organisations competing for the resources)?
- Its complementors (organisations in synergy for the resources)?

Will the envisioned change (during, after) influence the behaviour of these actors, and if so, how? Will new actors enter? If yes, what are their respective value chains?

**Table 1** Contents and deficiencies (relative to our objective) of the two models

Used model	Accounts for	Ignores
Arena	Substitutes products The value chains of the substitutes products	The coopeitition phenomenon The complementors The time dynamics within the network
Value net	The coopeitition phenomenon The competitors The complementors The various roles played by the same actor, which lead to the network concept The time dynamics in the network	The own value chains of the actors belonging to the network

**Fig. 2** Systematic competitive model of the product system



How may all of the organisations identified (including those linked by their multiple roles) move in response to the change?

The categories of organisations that will inform the model are determined in response to these questions. Of course, the choice of how to place an organisation within each category depends greatly on the product and the central firm. It is based on elements available in the bibliography, grey literature, and surveys. If we had used this model in the two cases mentioned at the very beginning of this article, we would have taken into account expropriated and displaced farmers. In the first case, competition over resources effectively is involved. The discovery that 20,000 farms risk being expropriated then is inevitable. In the second example, the model seeks competitors around the foreign company. It will discover the competing milk supplied by the Sahelian pastoralists.

The system described thus is like a tree linking the central firm with all of the organisations that supply it or that receive flows of goods and services, the latter themselves linked to other organisations ... continuing indefinitely. Furthermore, other organisations (and their respective value chains) are linked to the central firm and figure in the description of the system as competition phenomena. It thus is essential to give oneself cut-off criteria.

### 3.2 Exclusion: significant dependency criteria

Following the review established by Jeorgensen et al. (2008), cut-off criteria depend on expert judgement (Spillemaeckers et al. 2004) or “social significance”

(Barthel et al. 2005). Weidema reminds us that ISO 14044 requires that “decisions regarding the data to be included shall be based on a sensitivity analysis to determine their significance” (Weidema 2005, p. 381). Furthermore: “Resources need to be expended on the quantification of such inputs and outputs that *will not significantly change the overall conclusions of the study*” (ISO 2006). As we already have seen, in SLCA, exchanges of services and interdependencies are considered in addition to physical flows. Consequently, by applying the citation of ISO to SLCA through analogy with ELCA, we obtain: “resources, services and interdependencies taken into account need to be expended on the quantification of such inputs and outputs that *will not significantly change the overall conclusions of the study*.” From the perspective of comparing states, this injunction means that one must take into account resources, services and interdependencies whose flows would be affected significantly by a change in state (e.g., doubling production). Yet, it is the organisations that modify these flows. In so doing, some organisations also modify their behaviour which has significant social effects. The behaviour in question is how they hire and fire workers, organise work, locate activities, and make important strategic choices. The organisations that must figure within the boundaries of the system therefore are those *whose behaviour that has a social effect is sensitive* (e.g., linked) to the functioning of the life cycle studied. These are the *organisations whose behaviour that has a social effect would change* if the functioning of the life cycle under study changed.

Among the organisations that contribute to the existence of a product, some are not influenced by the functioning, or even the existence of the product, even if an ingredient or

service required for the manufacture of the final product pass through them. These organisations are not concerned by the social effects of the social life cycle of the product.

The cut-off criteria proposed is completely unrelated to the “responsibility” of firms. It does not help pass judgement on the moral responsibility of a firm that puts a dangerous product on the market or that contributes to the existence of such a product. The cut-off criterion defines itself through a comparison of two states and relies on the dependence between organisations. The organisations to include in the social life cycle of product X are those that would change their behaviour that has a significant social effect in response to a change in the scenario to produce X.

In the language of ISO standards, the overall conclusions of the study will not change if one chooses to exclude the inflows and outflows of a partner whose behaviour is independent of the functioning of the life cycle. Consider a supplier B of the central firm A. Imagine whatever changes may be made by A, the firm B's behaviour that have social effects remains the same. B then has nothing to do with the social impacts produced by the functioning of firm A's product X. To give another example, a mono-product manufacturing firm A clearly must be included in an SLCA study of the life cycle of its sole product, but this is not evident for a multi-product manufacturing firm C. If the disappearance of product X changes nothing in the behaviour of firm C, it would be illogical to attribute social impacts caused by C to the functioning of the life cycle of X. This is why, like Dreyer et al. (2006) had foreseen, the *influence* of the central firm (Gereffi et al. 2005) is critical in determining boundaries.

We name the cut-off criterion *significant dependency criteria*. In effect, supplier B will be included only if its client A (itself dependent on the functioning of the life cycle of product X) represents an important market for B. For organisations that maintain relations other than that of suppliers–customers with the central firm, one must estimate whether the effects of change initiated by the central firm will be important to them, *using known technical functions*. For example, let us assume that a complementor D sells an additional rice cooker when A sells 200 kg more of rice. This trivial technical function allows effects of a change in the activity of the second to be anticipated on the first. If the effects appear important, it is necessary to quantify them (even approximately) in order to calculate the portion of the social effects (e.g., through the creation of jobs) caused by D (rice cooker) that may be attributed to the change in the functioning of the social life cycle of the product (rice). One must note that once an organisation is excluded using this criterion, its entire value chain automatically is excluded as well.

By proceeding in this way, one avoids leaving out suppliers that contribute little to the material formation of a product, but for which the market is vital. Norris (2006) showed

that despite a small contribution (under 10 %) to the Dutch Electric chain, non-OCDE countries drew from this outlet a very important benefit in terms of life expectancy. Some firms are linked closely to the destiny of a product (e.g., complementors) without having any exchange with the central firm or its value chain.

The suggested cut-off criterion justifies the implicit choices made in numerous published SLCA studies. For example, national and local governments rarely are included in studies of life cycles managed by private enterprises. Likewise, major banks rarely are affected by the loss of a single client. Save for exceptional cases, their exclusion from the boundaries consequently is justified. Even more so, the social effects of large distribution firms are rarely attributable to the life cycle of a product supplied by a single manufacturer. In contrast, some markets are very dependent on the fate of a product. They, therefore, must be included in the boundaries of the system. The same is true for recycling and disposal.

### 3.3 Determining actors affected by the change

The boundaries of the study contain all of the organisations whose behaviour that have social effects will be affected significantly by the planned change. This response to change will generate social effects that can transform themselves into social impacts as soon as social groups experience them (van Schooten et al. 2003).

The determination of the social groups affected depends on (1) the type of impact, and (2) the organisations included within the boundaries. For example, if one is looking for the social effect of a change in terms of job creation or loss, this effect can affect workers through the organisations within the boundaries that have employees. Those without (e.g., an association without a paid employee) do not pass on this effect. Those that have employees but which are not included within the boundaries do not matter in the study.

To give another example, if the impact sought is the effect of a change envisioned on the health of populations in certain poor countries (as shown by Norris 2006), the actors affected are the entire populations of these particular poor countries, and not of other poor countries, nor other social groups.

Let us now return to the two examples given at the very beginning of the article, with the hypothesis that one is interested in changes in poverty or health. The discovery that 20,000 farms risk expropriation leads to the discovery of the social groups affected, which are all of the families making their living directly or indirectly from these farms. The same is true of the second example.

#### 4 Field test: comparison of two methods of delineating the boundaries

The objective of Section 3 is to compare, in a simple case, the results of two studies (of the effects of the same change) based on two ways of describing a system. We do not claim to be assessing social impacts here because the case study is too simple for that. Our only objective is to highlight the differences in results that are caused by differences in the methods.

In the two cases, the activity chain and the factual data (technical, economic, etc.) are identical. The first assessment describes the system using the value chain while the second uses the systematic competitive model. The same significant dependency cut-off criterion is applied in both cases.

The only social effect assessed in this example is the number of potential jobs destroyed or created. It is only the first step in the calculation of social effects caused by a strategy shift in the target industry. It is an important social effect that can induce, depending on the circumstances (Jeorgensen et al. 2010), major social impacts. Hunkeler (2006) already has studied social impacts induced by job creation.

##### 4.1 Context

The question to be addressed is whether or not transnational companies (current foreign suppliers of facilities for pig farms) should be allowed to set up new industrial farms in Croatia.

The Republic of Croatia (4,400,000 inhabitants) is situated in the North Western Balkans, connecting central Europe to the Mediterranean. After declaring independence from the former Yugoslavia in 1991, Croatia became engaged in an armed conflict that formally ended with the 1995 Dayton Peace Agreement. In 1999, the political landscape changed, and since that time, Croatia has undergone privatisation and other structural reforms in the expectation of being integrated into the European Union (Arcotress 2006). As a candidate country for EU membership, Croatia has been obliged to harmonise its agricultural policies with the *acquis communautaire* (MAFWM 2009).

The process is calling into question the future of the pig production sector (Krivec and Sreckovic 1989). It accounts for 33 % of livestock production (MAFWM 2009), with pig meat accounting for the greatest share of meat consumed. The total number of swine livestock is about 1.1 million (CBSRC 2009) on recorded<sup>3</sup> holdings. Croatia is nearly self-sufficient in pig meat, and prices for pigs are slightly

higher than in the EU (Arcotress 2006). The country imports piglets (2 % of total imports, average 2006–2008), and pig meat (3 %) (MAFWM 2009). The imports mainly come from Germany, Netherlands, Austria, Italy, Spain, Denmark and Hungary (IFIP 2010). Most pig farms are set up in the Northeast zone (Pannonian region), which enjoys the best agricultural potential. The five Croatian counties producing pigs are located around the main consumption zone (city of Zagreb).

Very small farms with less than ten sows account for 85 % of all pig production in the country (Antunović et al. 2004). Pigs are fed local agricultural feedstuffs. Wellbrock et al. (2009) distinguish three categories of farms in Croatia (Table 2) according to their size. The first includes these very small, traditional farms households, producing primarily for their own production; the second category consists of business-oriented agricultural households, called “full-time family farms”; and the third consists of large pig production sites managed by agronomists and run by business companies which own or rent extensive areas of land that are known as “farm enterprises”.

In 2008, it was planned (but ultimately not implemented) to allow transnational firms to set up new farm enterprises that would include 250 production units holding an average of 150 sows, as well as breeding (nucleus farms) and fattening farms to accompany this new production capacity (we shall refer to the entire project hereafter as the Pig Plan).

One might expect that the market for pig meat had the capacity to slowly expand as annual pork meat consumption was only 33 kg<sup>4</sup> per capita in 2003 (43.4 in EU-25) (Arcotress 2006, from Central Bureau of Statistics, Household Budget Survey 2003). However, the Croatian diet resembles that of Mediterranean countries, and the annual per capita consumption of meat (88 kg) in 2003 was already almost as high as that in the EU 25 (Arcotress 2006). The Pig Plan was not based on the expectation that there would be an expansion of pig meat consumption, nor that there would be a change in the comparative prices of different meats. Neither direct nor indirect rebound effects (Hofstetter and Norris 2003) thus were expected. It was clearly stated by the Ministry of Agriculture that the new farms would replace some old ones (Wellbrock et al. 2010).

##### 4.2 Assessment methods

###### 4.2.1 Choice of social effect assessed, of the functional unit and of the central firm

We take into account the *rural* jobs (jobs located in rural areas) because the socioeconomic context of the country

<sup>3</sup> The farm register of MAFWM only registers agricultural holdings which receive state support from the agricultural budget and/or which actively sell their products on the market.

<sup>4</sup> The annual pork meat consumption in France is 34 kg per capita in 2009 (IFIP 2010).

**Table 2** Characteristics of the three different pig systems

	Part-time family farms (N=7)	Full-time family farms (N=6)	Farm enterprises (N=4)
Number of breeding sows on farm	2.0±1.7	43.2±32.1	100 and 1,350
Number of pigs on farm (excluding piglets)	1–8	12–590	100–2,000
Farm size	4.3±5.2	42.2±44.3	Not relevant
Number of labour units (full time equivalent)	3.0±2.2	3.0±0.8	7.0±5.5

Source: from Wellbrock et al. (2009, p. 29)

values them highly, as shown in the grid (Table 3) established by Jeorgensen et al. (2010).

The chosen functional unit is the quantity of pork meat produced per year from livestock on a single new Pig Plan farm and made available to consumers in the country. This represents about 164<sup>5</sup> tons of meat per year. This unit evokes the principal goal of the Pig Plan, which is to produce pork meat. Results are expressed in rural jobs created and rural jobs destroyed by each new Pig Plan farm established. The latter is the *central firm* of the model.

#### 4.2.2 Making the calculation using the value chain method

We identified the 11 types of organisations directly invested in the value chain of the central firm. We then applied the significant dependency cut-off criterion to define which types of organisations should be included within the boundaries of the study. As we are only interested in variations in the number of rural jobs, we are responding here to the question of the influence of the central firm uniquely in terms of influence on rural job creation/destruction change. Among the organisations included, we then identified those in which the number of jobs would be modified by the implementation of the Pig Plan. The organisations taken into account thus were the 19 nucleus farms, the 250 new farms, the 73 fattening units, and the slaughterhouses and meat processing facilities. We calculated the number of rural jobs created based on different sources. The detailed calculations are provided in Electronic Supplementary Material 2. We then calculated the total number of rural jobs that would have been created by the implementation of the Pig Plan, by functional unit.

#### 4.2.3 Making the calculation using the second method

We described the system following the systematic competitive model. Beyond the 11 types of organisations described by the value chain, we found organisations that could play a complementor or competitor role, either with regard to suppliers or to clients. This step required extensive exploration of unpublished literature. The purpose of the Plan was

to replace traditional farms by new farms while keeping the same market prices, slightly above the EU price, and the same balance with other meat sources. This is why beef and other meat were not considered to be threatened by the Pig Plan. It is unlikely that the country would export pork meat. Furthermore, the new farms would be situated in the same geographic areas as the old ones. The new supply therefore would not find a market without taking the place of pork meat currently being marketed.

We identified in this particular context that full time family pig farms (the second of the three categories proposed by Wellbrock et al. 2009) would be in potential competition with the Pig Plan. All production of the new farms would replace the equivalent quantity of production of the full time family farms. The next step was to identify the entire value chain of these family farms. We then assessed the effects of this competition on the entire value chain in terms of rural jobs created and destroyed thanks to the technical functions linking the family farm and its partners in its own value chain (see Electronic Supplementary Material 2). We then calculated the total number of rural jobs on one hand created, and on the other, destroyed, under the hypothesis that the Pig Plan was implemented.

## 5 Results

### 5.1 Results of the effects of change when the system is described by the value chain

As described in detail in Electronic Supplementary Material 2 (Table S1), the organisations involved in the value chain and where the Plan could create jobs are the Pig Plan farms and the slaughterhouses and meat processing facilities. The calculation is indicated in Table S2 of Electronic Supplementary Material 2.

Under the value chain approach, it would appear that the Plan would create over 13 rural jobs per functional unit.

### 5.2 Results of the effects of change based on the second model

By systematically examining the types of organisations in competition or synergy with the Pig Plan farms, we spotted the farms specialised in pork production that were the full-

<sup>5</sup> The calculation was: 150 sows per new farm means seven packs of 21 sows; thus, 147×16 fattened pigs/sow/year×70 kg carcass/pig (see Electronic Supplementary Material 2)

**Table 3** Modifying sectors on societal level, which has an influence on how unemployment impacts the individual, and state for society

Modifying factor identifiable on societal level	State of the factor for society as a whole	State of the factor for the rural areas
Level of unemployment in society	Key economic problem	Declining labour opportunities in agriculture
Level of social security	Health and pension system	31 099 unpaid family workers have been accounted for (2001).
Labour market programmes	Benefit system for official workers	Benefit system for official workers
	Against discrimination (2010)	Not for unpaid family workers
Level of social security to increase income	Social assistance up to subsistence level per family	Smallholders can receive income support, and apply for rural development schemes.
	Social inclusion programme (2011)	

Source: adapted to the case from Jeorgensen et al. (2010, p. 381)

time family pig farm type (Wellbrock et al. 2009). For the reasons presented in Electronic Supplementary Material 2 (& 21), they would be in direct competition with Pig Plan farms for the same markets (supermarkets). Consequently, the installation of each new Pig Plan farm would force out of pig production some family farm organisations, at a rate proportional to the quantity of meat.

Table S3 in Electronic Supplementary Material 2 recapitulates the different types of organisations where the creation and destruction of rural jobs are located, both in the value chain created by the Pig Plan and in that of full-time family pig farms. Table S6 in Electronic Supplementary Material 2 presents the calculations.

By using the systematic competitive model, it appears that implementation of the Pig Plan would lead to the creation of two rural jobs and the destruction of between seven and 13 rural jobs, for the creation of each new farm.

The number of existing farms threatened is 1,095 (MAFWM 2009). The objectives of the Pig Plan (+600,000 fattened pigs per year) are therefore the equivalent of the total 2009 production of full-time family pig farms ( $1,095 \times 42$  sows  $\times 15$  pigs/sow/year = 689,850 fattened pigs/year). The Pig Plan thus potentially could replace pork meat production from nearly all existing full time family pig farms.

Even if the calculations are approximations, the picture that emerges in the second case appears to be the opposite of the first. Instead of creating 13 jobs with each new farm, the Pig Plan would likely destroy rural jobs. It is thus an important issue in Croatia. Even if the farms concerned converted to other agricultural activities or off-farm activities, the jobs in the abandoned pork activity would be lost. Moreover, unemployment remains one of the key economic problems for Croatia. The level is still double the EU average (Arcotras 2006). Survey unemployment rates were 20 %, against the 14 % registered unemployment rates in 2003 (Sosic 2005). The real level is estimated to be 16.10 % (2010) and 17.60 % was planned for 2011 (CIA World Factbook 2010). Unemployment is a particularly sensitive

issue in agriculture, because 10 % of the working age population earns their income from agriculture and the food industry. A total of 99,000 people (2005) are officially employed in the agricultural sector, but this under-represents the real significance of the sector in employment, given that there are an estimated 450,000 agricultural holdings and over 45 % of the total population lives in rural areas. Between 1999 and 2003, official employment in agriculture decreased roughly by 28 %, whereas official employment in the food industry remained stable around 45,000 people (Arcotras 2006). Jobs in agriculture and food industry are gaining increasing social value (Arcotras 2006, p. 14). There is no security system for agriculture workers who lose their jobs. Moreover, numerous people are unpaid family workers (with two or three women for every man), and there are still 300,000 smallholdings today. The family workers are making their living on these farms. The competition with the planned new farms would destroy the jobs of some official workers and the jobs of many unpaid family workers. In this context, their chances of finding another job are extremely limited.

## 6 Discussion and conclusions

### 6.1 Advantages and limits of the systematic competitive model

The example given in Section 3 focuses on a sole social effect, the creation/destruction of rural jobs. The approach may be applied, however, to other social effects. The same reasoning prevails if one wishes to assess the effect of a change on the health of workers, for example. Beyond the workers of suppliers, it appears justified to worry about changes in the health status of all workers in all of the organisations affected by this change.

We suggest that it is always relevant to represent the product system by the organisations linked by flows of resources and services. Likewise, we suggest always that

the significant dependency cut-off criteria should always be applied. In this way, only social effects potentially caused by a change in the product chain would be attributed to *this* product chain. In other words, the social effects are attributed to a product on the basis of the “social responsibility” of firms, which is a different concept. Here, in contrast, the social effect only is attributed to the functioning of the social life cycle of a product if it is caused by a change in the behaviour of an organisation that is significantly dependent on the product.

However, all cases cannot fall within the scope of the same system description model.

The value chain suffices to describe the social life cycle on an expanding market among consumers and suppliers (which furnish as much as is wanted) when there are no important synergies with other chains. If one of these conditions is not fulfilled, the systematic competitive model must be used. This model is a *minimum* model. We say minimum because the functioning of product chains have many other social impacts related to cultural, political, and institutional effects, on innovation, etc. Approaches that pay attention to producers which are not participating directly in the value chain are rare, but they reveal relevant social effects (Neilson and Pritchard 2010). The sphere of effects is vast and the real boundary of an SLCA study is that which includes the sources of all of the effects of this effects sphere! Yet with the current state of our knowledge, we do not know how to model this real boundary. The model proposed is just a first step, one that can address simple cases of competition, and for short-term effects only!

This first paper also presents a simplified version of the system. It ignores the competition between partners of the central firm, for example. The rules proposed also are rough, and should be made more precise. For example, in the case study, we mixed together the step of identifying the general influence of the central firm with the step where we seek the influence of a change uniquely on the creation/destruction of rural jobs. As a general rule, the two steps should be distinguished, which leads us to define precise criteria for “significant dependency”. Let us note again that the criterion does not depend on the “responsibility” of organisations, but on the influence of a change in scenario on the behaviour of organisations that have social effects. Considerable conceptual work and multiple case studies still need to be conducted.

In the general case (that where there is competition), defining the system and its boundaries is not an easy task because if they are too narrow, they will be simple but major actors will be left out. If they are too broad, it will be complicated to understand and there will be an increased risk of error, without mentioning the time and expense required by such studies. A general method of describing a system and of delineating boundaries therefore seems

useful. The approach is summarised in a chronological manner in Table 4.

This approach does not exclude the consideration of stakeholder opinions in any step. To the contrary, they must be solicited to define who the competitors are prior to the design of the perimeter, and to verify if the outputs seem in accordance with their own knowledge of the industry.

## 6.2 Validity and precision

The use of the competitive model requires a fine understanding of the socioeconomic context and the activities involved. It likely will be difficult to always anticipate with precision the effects of changes of the central firm on its partners in the arena. The results are not always very precise, but this strikes us as being preferable to complete ignorance. The objective of the case study is not to provide a veritable evaluation of the potential effects of the Pig Plan (which would require field surveys). It is to show the considerable differences between results depending on whether the system is defined using the value chain or the systematic competitive model. To describe the system by the value chain returns to describing it by what Jeorgensen et al. (2010) call “the state”, rather than “change”. In their view, “Assessing only the state [not the change] and basing one’s decision on that would not be better than basing ones decision on no assessment at all” (Jeorgensen et al. 2010, p. 382). Actually, “what is needed [–] are assessment methods allowing to distinguish between developments which are more or less sustainable and those which are not at all” (Klöpfle 2003, p. 157). In the case study, the first assessment (by the value chain) calculates the creation of rural jobs by starting from a clean slate! Meanwhile, the second (thanks to the systematic competitive model) describes the probable changes in relation to the current situation. The first social life cycle model is deceptive.

If we were conducting ELCA, our approach would be likely described as *consequential modelling*. This has been recognised by the International Reference Life Cycle Data System (ILCD) Handbook as theoretically the most appropriate choice for LCAs that are intended for decision support because they provide more meaningful results and better reflect the societal benefit (Schmidt and Weidema 2009). From the general review recently depicted by Earles and Halog (2011), consequential LCA covers several different areas. The same word brings together ELCA studies about (1) the marginal substitution of one product by another, not affecting the rest of the society; (2) larger changes involving partial equilibrium modelling, and (3) the largest changes driven by global equilibrium modelling. Our proposition belongs to the first category of consequential LCA. “The changes in demand are normally regarded as being small

**Table 4** Summary of the proposed approach

Chronological step	Focus on	Then, identification of
Central firm	Product chain X	Who is the central firm?
Supply chain	Flows of goods and services to and from central firm	What is the value chain?
Competitors and complementors	<i>Systematic competitive model</i> implemented: “If main change affects the product X...”	What are the organisations potentially affected by the change?”
Implementation of the cut-off criteria	Technical functions between the organisations potentially affected by the change and the central firm	What are the organisations really strongly affected?
Affected actors	For one kind of impact w, and knowing the organisations really affected	Who are the affected actors?
Calculation of impact w	Impact pathway of w	Quantified impact w for each group of affected actors

compared to the production in society in general, which is therefore assumed unchanged. This means that the change is analysed in isolation under a *ceteris paribus* condition” (Weidema et al. 1999, p. 48). Our scope is not society as a whole, nor the whole sector (like in partial equilibrium modelling), but rather the strategic arena of the central firm. As mentioned earlier, the time horizon of the systematic competitive model is very short (around 1 year) because cooptition in business changes very fast. In consequence, our model refers to only a narrow portion of consequential ELCA cases described by Weidema et al. (1999).

We seek the validity of the approach rather than the precision of the calculations. We return to Weidema's remarks regarding the choice of attributional modelling instead of consequential modelling in ELCA. He explains that avoiding uncertainty by using attributional modelling “is simply the same as ignoring the true uncertainty of the consequences of the decision” (Weidema 2009, p. 355).

### 6.3 Coherence between the boundaries of ELCA and SLCA

The question of the coherence of SLCA and ELCA systems and boundaries is very important. What does it mean for decision makers who must, for example, choose between scenario A (with change in an activity) and scenario B (without change)? Decision makers need to know how the environmental and social effects of scenario A compare with those of scenario B. It therefore is critical for each *scenario* (meaning the detailed account describing the situation with or without change) to be *strictly identical, whether it is assessed by ELCA or SLCA*. As long as they are identical, it does not matter if they are incomplete or very detailed, whether they include or not more or less long term consequences for the central firm, or whether they gather together data of diverse quality. Swarr emphasises how important it is for ELCA and SLCA boundaries to be “consistent ... to obtain technically valid results” (Swarr 2009, p. 287). This

coherence is obtained through the identity of the scenarios submitted to study by the two methods.

While they work from the same scenario, ELCA will not represent the actual system in the same way as SLCA. Logically, the cut-off criteria are different. One will not be able to ignore the same processes or organisations in the two types of studies. On one side, one must ignore minor sources of environmental effects, on the other, minor sources of social effects. The two types of effects rarely pass, furthermore, by the same vectors. No one is surprised that one uses different inventory data in ELCA than in SLCA. The same is true for the description of the system and for the boundaries. This conclusion disturbs the practices and perhaps the hopes of LCA supporters, but is there a way of proceeding together?

As noted in the guidelines, “There is an important need for research concerning the elaboration of social and socio-economic mechanisms” (UNEP/SETAC 2009, p. 73). This paper is based on certain concepts created in economics and strategic studies to describe such mechanisms. We have hybridised them to propose a method to construct the social life cycle. This is a response to the double wish formulated by Hunkeler and Rebitzer to build the social dimension as an independent dimension of sustainability, and to involve social sciences more deeply. “For both validity and acceptance it is essential to interact with the social and socio-economic sciences” (Hunkeler and Rebitzer 2005, p. 307). Here, we provide a reading of the system and of boundaries borrowed from strategic studies, like Swarr (2009), following Hutchins and Sutherland (2008), as O'Brien et al. (1996) suggested. As Dreyer et al. (2006) foresaw, relations of influence between organisations must be acknowledged to track the social effects of product life cycles up to the actors affected.

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